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DEPARTMENT OF COMMERCE
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Letter
Circular
LC-412

DOMESTIC ELECTRIC AND GAS REFRIGERATORS

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(Replaces LC-297)

This letter circular has been prepared to serve as a reply to numerous requests for information on refrigerators. Many of these requests are for recommendations or opinions on specific makes of machines, or for results of tests made by the Bureau. It can be stated at once that it is not one of the functions of the Bureau to collect or distribute information on the relative merits of commercial products, nor to give opinions or make recommendations concerning them. A very few tests of refrigerators have been made by the Bureau to determine compliance with requirements of other government departments. The latest tests were made years ago, so that the results are not applicable to machines now being sold.

This circular deals with the type of domestic machine which is complete in itself, and statements made here may not be applicable to the so-called multiple systems installed in many apartment houses, in which a number of refrigerators are connected to a single compressor.

General Types of Refrigerators

There are two general types of refrigerating systems, the compression and the absorption type. The compression type consists essentially of three parts, a cooling unit, which is inside the refrigerator, and a motor driven compressor and a condenser outside. If the machine has been running and is then shut down, there will ordinarily be some liquid refrigerant in the condenser under high pressure, and some in the cooling unit at lower pressure. As the refrigerator and cooling unit becomes warmer, an automatic switch starts the motor. The compressor then removes vapor from the cooling unit, so that the liquid therein can evaporate at low pressure and temperature, and thus effect cooling. The compressor, taking the vapor from the cooling unit at low pressure, must compress it to a pressure sufficiently high to cause liquefaction in the condenser, from which heat is removed by the air. The liquid from

the condenser then passes through an expansion valve or equivalent device, to the cooling unit, so that the operation is continuous as long as the motor runs. When the cooling unit and refrigerator have cooled sufficiently, the automatic switch stops the motor.

In the absorption type the vapor from the cooling unit is absorbed in a suitable substance, such as water, or other liquid, or by a solid which is capable of absorbing large quantities of vapor. Subsequently, the substance containing the absorbed vapor is heated, either electrically or by a flame, and the vapor is driven off, then cooled and condensed to a liquid, which is returned to the cooling unit. Machines of this type have few or no moving parts, and practically all of them are almost noiseless in operation. Some of the machines using a liquid absorber are continuous in operation, the heat being applied always to one part, while the liquid is caused to circulate. Others are of the intermittent type, the heat being supplied for a time to one part, then to another part, or to one part at intervals.

Nearly all of the machines now on the market are designed to provide for freezing ice cubes, and since this feature is so very generally included, no further consideration of it is required here.

A very large number of makes of refrigerating machines of the compression type have been put on the market. These have included such variations as direct drive, belt drive, and gear drive; reciprocating single or multiple cylinder compressors, various types of rotary compressors; various refrigerants such as sulfur dioxide, methyl chloride, ethyl chloride, ammonia, volatile hydrocarbons, and more recently, materials known by trade names such as freon, carrene, etc.; refrigeration by direct expansion or by the use of brine tanks, etc. Completely sealed machines of the compression type are also available and are offered by several manufacturers. It is impracticable to discuss here the various merits and demerits of the features which are often emphasized out of all proportion to their importance, in advertising and by salesmen. The user of a machine is not so much concerned with the kind of drive, refrigerant or absorbent used, type of compressor or system of refrigeration as he is in the kind of service the machine will give and what the service may cost over a period of years. For example, a machine with a rotary compressor may be either better or worse than one with a reciprocating compressor,

since the success or failure of either will depend upon the quality of the whole machine and not upon such a single feature of design.

Selection of a Refrigerator

Knowledge of details of design is of value to the expert in judging whether the machine is designed and made so that it can be expected to have a reasonably long life and give satisfactory service during its life. The fact that a machine has one or several features of design which seem superior does not necessarily indicate that it will prove to be superior to other machines having other features of design. For example, the refrigerant used is a factor of minor importance as regards efficiency, since machines can be designed to use any of the ordinary refrigerants effectively. Similarly, either compression or absorption machines can give very satisfactory service.

Short-time tests of refrigerating machines unfortunately can not furnish complete information as to their relative merits. Such tests may disclose obvious defects and will readily show the power or gas consumption and the efficiency of the unit at the time of test. By operating the machine under extreme conditions, for example, at high room temperatures, it is possible to make an estimate of the margin of reserve in power, cooling capacity and strength of parts above ordinary requirements, but none of these tests gives information on the most important points, namely, the durability and reliability in service of the average machine under ordinary conditions.

Fortunately, the problem of selecting the "best" machine does not now have the importance it may have had at one time. There are a large number of machines on the market any one of which may be expected to give satisfactory service. Undoubtedly, some are better than others, and some are better investments than others, but so far as is known to the Bureau, tests sufficiently comprehensive to bring out such differences could not be completed before the machines under test were superseded by later models so that even if such tests were attempted they would be useless by the time they were completed. It is true that when thousands of machines are manufactured and sold, some proportion of even the most carefully made ones will prove defective, and perhaps none will be perfect. However, unless one happens to make an unfortunate choice, he may expect to obtain about as satisfactory a machine as his neighbor who choses a different make.

Dependable and authentic information on the electric energy or gas consumption of the various makes and models of refrigerators, under standard test conditions, would be of value to the prospective purchaser, but so far as is known to the Bureau, such information is not available. An objection to publishing such information is that the machine showing lowest consumption would have such an advantage that manufacturers would be compelled to sacrifice other qualities, possibly dependability or durability, in order to produce machines of very low energy consumption.

Hazards of Refrigerants

Recently a number of new refrigerants have been developed, which are intended to reduce the hazards which might accompany leakage of the refrigerant from the machine. The hazards which might result from leaks are those of fire or explosion, or of poisoning. Obviously, as long as the machine is free from leaks, these hazards are absent. It is true that in larger refrigerating or air conditioning systems, which may contain large quantities of refrigerant, the safety qualities of the refrigerant are of the utmost importance. However, the question of hazard in connection with domestic units has been much emphasized in advertising and sales promotion, and many prospective purchasers have been sorely puzzled thereby, even though very few of them purchase a machine with the expectation that it will leak. It should be emphasized that the amount of refrigerant used in domestic machines is small, about one pound, and the hazards of any of them are less than those of ordinary gas-burning appliances.

As concerns the fire or explosion hazard, only those refrigerants which will burn in air, present such a hazard. Sulfur dioxide, carrene, and freon will not burn. Refrigerants which will burn very readily include butane and isobutane which are comparable with gasoline or fuel gas, while ethyl chloride and methyl chloride burn less readily and ammonia burns with difficulty. If a refrigerant which will burn escapes in sufficient quantity in a short enough time, and is ignited at just the right time and place a fire or even an explosion may result.

As concerns the danger of poisoning by breathing air mixed with the vapor of the refrigerant, many of the inquiries received indicate that the writers recognize only two classes of substances, those which are poisonous, and

those which are not, and that they also believe that a mere whiff of a poisonous gas will kill instantly. The fact is that all refrigerants in common use will, if in sufficient concentration, produce pathological effects which may range from mild anaesthesia to severe disturbances or even death. The severity of the effects with a given refrigerant will depend upon its concentration in the air, and the length of time the mixture is breathed. Some of the refrigerants are much less poisonous than others.

Persons who have used household ammonia know that a single whiff of ammonia is not immediately fatal, while many persons who have used the old fashioned sulfur matches or sulfur candles have experienced the effects of sulfur dioxide. Yet a much smaller amount of one of these substances is required to produce irritation or illness than of any of the other substances commonly used in domestic refrigerators. A small amount of ammonia or sulfur dioxide produces no effect other than temporary discomfort, but the amount in a household refrigerator is sufficient to produce serious effects, if all of it is released at once in a moderate sized room and breathed for any length of time. The atmosphere, however, would be so irritating that any person at all able to do so would speedily depart.

Some refrigerants, such as carrene and freon, which are comparatively safe of themselves, are decomposed by heat, for example, by passing through the flame of a gas burner, and the products of decomposition are distinctly irritating and poisonous. Ethyl chloride and methyl chloride yield similar products when decomposed by heat. It is very improbable, in a domestic installation, that dangerous conditions will be produced in this way.

It is always possible to imagine or arrange conditions, for example, a small unventilated room from which a person could not escape. where the discharge of the refrigerant from a machine might produce serious or even fatal effects. However, the amount of refrigerant used in a self-contained domestic unit is so small and the natural ventilation of most rooms is so effective that a very unusual combination of circumstances is required to introduce a serious hazard in the relatively few cases in which leaks do occur.

As concerns spoilage of food by the refrigerant in case of a leak, it may be said that if spoilage is not indicated either by appearance, odor or taste the food is probably fit for use, but if there is any doubt it is far better to throw

the food away than to worry about it.

This discussion of hazards may be summarized in two statements, first, that the ideal refrigerant, which has all desirable properties and lacks all undesirable ones, has not been and perhaps never will be discovered, and, second, that the kind of refrigerant used in a domestic unit is much less important than other factors to be considered in the purchase of a refrigerator.

Important Factors in Choice of a Refrigerator

1. Record of the manufacturer and the machine. A newly developed design may represent a distinct advance, but there is a greater risk that it may prove unsatisfactory than in the case of one which has stood the test of service.

2. Noise. Unless a machine runs quietly when new and continues to do so, it will be unsatisfactory to most of its users.

3. Useful life. The aggregate cost of refrigeration depends to a considerable extent upon the length of life of the machine, and upon the cost of service and repairs. Very little information on this point is available, and the purchaser must depend upon the reputation of the product and such information as he can find in regard to durability.

4. Efficiency of the machine. There are some differences in the operating efficiencies of different machines, and figures on operating costs can sometimes be obtained. If a machine is not well made or is allowed to deteriorate, efficiency may be greatly reduced after a short period of use.

5. Insulation of the refrigerator. The refrigerator should be well insulated, preferably with not less than a two-inch thickness of some good insulating material or its equivalent. Refrigerators depending largely upon ordinary air spaces for insulation or those with thin walls and doors are likely to require considerable power or fuel to keep them cold.

6. Convenience and ease of cleaning. Such items as shelf arrangement, etc., are of importance to the user. In some locations a machine with door hinges at the right may be much more convenient than one with hinges at the left or vice versa. In many cases this feature is not noticed

until the refrigerator is installed.

7. Attention required from user. If attention such as oiling or adjustments are required from time to time, the points requiring attention should be few in number, and should be readily accessible where the machine is to be installed, lest it suffer from neglect.

8. Servicing the machine. Any machine is likely to require service or repairs at some time or other, and it is important to know whether satisfactory local service facilities are available.

Other Sources of Information

1. "Household Refrigeration", 4th Edition, by H. B. Hull, published by Nickerson and Collins Co., Chicago, 1933, 700 pages, $4.00

2. A booklet entitled "Home Economics Bibliography 5 - Household Refrigeration". This booklet, containing a list of references to articles, mostly non-technical, of interest to the householder, may be obtained free from the Bureau of Home Economics, Department of Agriculture, Washington, D.C.

3. The Household Refrigeration Bureau of the National Association of Ice Industries, Chicago, Ill., issues pamphlets on household refrigeration and related subjects.

4. Bureau of Standards Circular No. 376, "Thermal Insulation of Buildings", contains a brief discussion of refrigerator insulation. This publication may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for five cents (stamps not accepted).

5. The Refrigerating Data Book, published by the American Society of Refrigerating Engineers, 37 West 39th St., New York City, has excellent technical chapters on such subjects as insulation, domestic refrigerators, as well as on commercial systems, 430 pages, $3.50.

Numerous papers on this subject may be found in the refrigeration journals listed below:

Journal	Published	Publisher	Address
Refrigerating Engineering	Monthly	Am. Soc. of Refrig. Engrs.	37 W. 39th St.,N.Y.C.
Refrigerating World	Monthly	The Ice Trade Journal Co.	Woolworth Bldg.,N.Y.C.
Ice & Refrigeration	Monthly	Nickerson & Collins Co.	5707 W.Lake St., Chicago.
Electric Refrigeration News	Bi-weekly	Business News Publishing Co.	554 Maccabees Bldg., Detroit, Mich.

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